EXD-R

Vol. 87. Part 16. Pp. 385-396, 1 pl. 25th October, 1938.

IMP. INST. ENT.
— LIBRARY —
28 OCT 1938
SERIAL
SEPARATE

THE

TRANSACTIONS

OF THE

ROYAL ENTOMOLOGICAL SOCIETY

OF

LONDON

World List abbreviation: *Trans. R. ent. Soc. Lond.*

CONTENTS

PAGE

COCKAYNE, E. A., D.M., F.R.C.P. Supernumerary antennae in insects . . . . . 385–396, 1 pl.

LONDON:
PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 4s. 6d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION 1938–1939.

J. C. F. Fryer, O.B.E., M.A., *President.*

H. M. Edelsten
A. D. Imms, M.A., Sc.D., F.R.S. } *Vice-Presidents.*
H. Willoughby Ellis, M.I.E.E.

Francis Hemming, C.M.G., C.B.E., *Treasurer.*

O. W. Richards, M.A., D.Sc., *Secretary.*

F. J. Griffin, A.L.A., *Registrar.*

Other Members of Council.

R. B. Benson, M.A.
Brig.-Gen. B. H. Cooke, C.M.G., C.B.E., D.S.O.
C. N. Hawkins.
L. G. Higgins, M.A., F.R.C.S.
B. M. Hobby, M.A., D.Phil.
Sir Guy A. K. Marshall, C.M.G., D.Sc., F.R.S.
N. D. Riley.
W. H. T. Tams.
W. R. Thompson, Ph.D., D.Sc., F.R.S.
B. P. Uvarov, D.Sc.
V. B. Wigglesworth, M.A., B.Ch., M.D.

Trustees of the Society.

R. W. Lloyd.
Sir Edward B. Poulton, F.R.S.

Finance and House Committee.

H. Willoughby Ellis, M.I.E.E. (Chairman).

Prof. P. A. Buxton, M.A.
Brig.-Gen. B. H. Cooke, C.M.G., C.B.E., D.S.O.
G. Fox-Wilson.
C. N. Hawkins.
R. W. Lloyd.

Publication Committee.

W. R. Thompson, Ph.D., D.Sc., F.R.S. (Chairman).

H. E. Andrewes.
M. Burr, D.Sc., F.G.S., A.R.S.M.
B. M. Hobby, M.A., D.Phil.
N. D. Riley.
V. B. Wigglesworth, M.A., B.Ch., M.D.

Library Committee.

R. B. Benson, M.A. (Chairman).

E. A. Cockayne, M.A., M.D., F.R.C.P.
H. M. Edelsten.
B. M. Hobby, M.A., D.Phil.
W. H. T. Tams.
B. P. Uvarov, D.Sc.

Committee for the Protection of British Insects.

W. G. Sheldon (Chairman).

Capt. E. Bagwell-Purefoy.
C. L. Collenette.
W. J. Dow.
J. C. F. Fryer, O.B.E., M.A.
Col. F. A. Labouchere.
N. D. Riley.
H. M. Edelsten (Secretary).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO:

1. **British National Committee for Biology** (Royal Society).
   Sir Thomas Hudson Beare, LL.D., F.R.S.E., appointed 1933.
   Dr. Karl Jordan, F.R.S., appointed 1936.
2. **Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science.**
   Sir Edward Poulton, F.R.S., appointed 1937.
3. **International Congress of Entomology** (Berlin 1938).
   J. C. F. Fryer, O.B.E., M.A. *Francis Hemming, C.M.G., C.B.E.*
   A. D. Imms, M.A., Sc.D., F.R.S.
4. **Local Committee of Management of Wicken Fen.**
   Mr. H. M. Edelsten. *Mr. E. C. Bedwell.*
   [Delegates nominated by Committee for the Protection of British Insects.]
5. **National Trust for Places of Historic Interest or Natural Beauty.**
   Mr. W. G. Sheldon, appointed 1922.
6. **New Forest Association.**
   Mr. W. Fassnidge, appointed 1934.
7. **Royal Meteorological Society. Phenological Committee.**
   Dr. C. B. Williams, appointed 1937.

SUPERNUMERARY ANTENNAE IN INSECTS

By E. A. Cockayne, D.M., F.R.C.P.

(Read 1st June, 1938.)

With Plate 1.

In this paper I have described and figured a few examples of supernumerary antennae and at the same time I have taken the opportunity of reviewing the whole subject of additional antennae in the Insecta and of collecting references to the published cases and classifying them. The presence of additional antennae may be due to various causes and I have arranged them in the following groups.

I. *Double monsters.*
II. *Abnormal development producing homoeosis, homoeotic reduplication, simple reduplication, or a combination of these abnormalities.*
III. *Homoeosis and homoeotic reduplication.*
IV. *Bilateral reduplication.*
  (a) Two extra antennae or parts of antennae on each side arranged in accordance with Bateson's Law.
  (b) Complete or partial duplication of the antenna on each side.
V. *Unilateral reduplication.*
  (a) With the whole or part of the antenna triple.
  (b) With the whole or part of the antenna double.

I. Double monsters.

Cappe de Baillon has shown that in Phasmidae eggs with two micropyles are not uncommon, and that they may produce double monsters showing all degrees of fusion. The condition is not determined genetically. Phasmids with two complete heads like the specimens of *Carausius morosus* Brün. shown in his figs. 34 and 39 are unmistakable.

I know of only one comparable example in another Order, a *Chironomus* larva (Dipt.) recorded by Weyenbergh (1873, *Stettin. ent. Ztg* **34** : 453) with two separate heads and thoraces. Double monsters with two abdomens, completely or partially separate, are commoner, such as *Melanitis leda* L. (Lep.) (Jordan, 1927, *Proc. ent. Soc. Lond.* **2** : 20), *Centrurus margaritatus* Gerv. (Col.) (F. Campos, *Rev. Col. Rocafuerte, Guayaquil* **1930** : 40) and a gynandromorph *Thaumatopoea pinivora* Tr. with bifurcate abdomen, the left male and the right female. The existence of these easily recognisable double monsters in various Orders is important as a proof that some of the more completely fused examples are caused in the same way. Cappe de Baillon gives figures (figs. 25, 26, and 27) of specimens of *Carausius morosus* Brün. with the heads completely fused and the appendages symmetrically arranged, having two antennae and two eyes on each side (figs. 25, 26, 27), or two antennae on each side and three eyes, the median one caused by fusion of an eye belonging to each component (fig. 24) or with three eyes and three

antennae, the third eye and antenna being median (figs. 12, 23). The median eye and antenna are usually imperfect. He also gives an example of a double monster with an asymmetrical fused head, in which an extra eye and two extra antennae are situated on the right side in front of the antenna belonging to the major part of the monster (fig. 37). In fig. 36 another double monster is shown with an additional antenna on the left side of the head, which belongs partly to the right and partly to the left component. Somewhat similar are the four shown in fig. 41, of which c and d have an additional antenna on the left with an origin distinct from that of the normal left antenna and showing their fused double character by branching into two parts towards the distal end.

The following are examples of the same kind in other Orders. *Olene leucophaea* Smith and Abbot (Lep. LYMANTRIIDAE) with four antennae, two central and two lateral. From their arrangement it is clear that the moth has a fused double head, and that one central and one lateral antenna belong to each component. (1904, *Psyche* **11** : 113.)

Leptura aurulenta Fabr. (Col. CERAMBYCIDAE) with two additional antennae arising from a single fused base near the median line. This is comparable with Cappe de Baillon's figs. 12, 23, and 24. (Bellevoye, 1908, *C.R. Assoc. franç. avanç. Sci.* **36** : 649, fig. 30.)

Coscinocera hercules Misk. (Lep. SATURNIDAE) with two antennae, smaller than normal, facing one another on the right side of the head and belonging to the right component of a double monster. (Oberthür, 1916, *Études Lép. comp.* **11** : 23, pls. 2 and 4.)

Meloë violaceus Marsh. (Col. MELOIDAE), female, with two very small imperfect antennae, with origins independent of one another and of the normal right antenna, lying between it and the right eye. (Kraatz, 1877, *Deuts. ent. Z.* **21** : 57, fig. 22.)

Saperda carcharias L. (Col. CERAMBYCIDAE) with a small additional antenna arising from a separate origin just internal to that of the normal left antenna and partially separated from it by a projection running forwards from the middle of the left eye. (Ritsema Bos, 1879, *Tijds. Ent.* **22** : 206, pl. 11, figs. 3, 4.)

Cerambyx cerdo L. (Col. CERAMBYCIDAE) with an additional antenna of two segments arising from an independent origin in front of and internal to that of the normal left antenna. (von Heyden and Kraatz, 1889, *Deuts. ent. Z.* **33** : 221, pl. 1, fig. 23.)

Saturnia pavonia L. (Lep. SATURNIDAE), male, with a small additional antenna arising from a point at some distance below the normal one. (Windhorst, 1914, *Ent. Z. Frankfurt* **28** : 3, fig.)

Doleschallia amboinensis Stgr. (Lep. NYMPHALIDAE). On the right side of the head two antennae arise close together, one above the other. The lower is slightly smaller, the upper is as large as the left antenna, and both are of normal thickness. (Oberthür, C., 1900, *Bull. Soc. ent. Fr.* **1900** : 53.)

Chrysomyza demandata F. (Dipt. MUSCIDAE). The lower part of the head on the left side is enlarged, displacing the left side of the frons upwards and the lower part of the opposite side of the head to the right. On the left side there are three perfect antennae all as large as that on the right. The upper one is displaced upwards and the ptilinum is probably pushed out of sight under the frons, the two lower antennae arise from separate origins close together below and internal to that of the upper one and separated from it by a ptilinum, probably a second one. Instead of one sclerite between the eye and labrum there are two. The full size, perfect development, and

independent origins of the three antennae, and the extra parts on the face make it almost certain that this is a double monster. (Collado, T. G. I., 1932, 5*e. Congr. int. Ent. Paris*, **2** : 285, fig.)

Syrphus perplexus Osburn (*arcuatus* auctt.) (Dipt.). Male. The right side of the head is normal, but on the left side the compound eye is wanting, and there is a third antenna posterior to the normal one, separated from it, and arising from a fossa of its own. It is normal in structure except that it is reduced in size and its arista is undeveloped. A second vertical triangle is present alongside the normal one, and is similar to it in pilosity and in the arrangement of ocelli, but the anterior median ocellus has no cornea. I regarded this as an example of homoeosis, but this would not account for the second triangle, and I think it is a double monster. (R. C. Osburn, 1908, *Science* **27** : 67 ; 1910, *J.N.Y. ent. Soc.* **18** : 62, pl. 3.)

Podagrica sp. (Col. CHRYSOMELIDAE) with an additional antenna on the left side of the head springing from a point between the clypeus and the labrum. (Heikertinger, 1915, *Wien. ent. Ztg* **34** : 335.)

Himera pennaria L. (Lep. GEOMETRIDAE) with two antennae on the left side of the head, one above and one below the left eye, and none on the right side. (Pierret, 1847, *Ann. Soc. ent. Fr.* (2) **5** : lxxxv.)

Cerambyx scopolii Fuessl. (Col. CERAMBYCIDAE) with two antennae on the left side of the head and none on the right, but with a fossa for the origin of the right one (scrobs antennalis dextra). (1886, Frivaldsky, *Term. Füzetek* **1886** : pl. 4, fig. 12.)

The abnormality in both the last two insects has been attributed to displacement of the right antenna to the left side through injury, but it is more probable that they are double monsters.

Callidium violaceum L. (Col. CERAMBYCIDAE). On the left side of the head above the eye are two antennae of the same length, and on the right side a single normal antenna. (V. von Roder, 1888, *Ent. Nachr.* **14** : 219.)

II. ABNORMAL DEVELOPMENT PRODUCING HOMOEOSIS, HOMOEOTIC REDUPLICATION, SIMPLE REDUPLICATION, OR A COMBINATION OF THESE ABNORMALITIES.

Many examples of the above phenomena have been found in *Drosophila melanogaster* Mg. by Morgan, Bridges, and Sturtevant (1925), and occur with such frequency in eyeless stocks and so seldom in any other, that these authors regard them as by-products of the mutant recessive gene. Sometimes an additional antenna appears in place of an eye and shows a serial homology with the antenna of the same side, *i.e.* it is not a mirror image of the normal antenna. Not infrequently, when both eyes are absent an additional antenna is found on each side. These are examples of unilateral or bilateral homoeosis. Very rarely two additional antennae are present on the same side in place of an eye and are mirror images of one another. This is homoeotic reduplication. Duplications of one or even both antennae sometimes occur in the same stock, and very rarely there may be an antenna in place of an eye in the same insect. The duplicated antennae are mirror images of one another. Another abnormality often found in association with these additional antennae of eyeless *Drosophila* is a palpus arising from the lower edge of the empty eye-space, and just behind it there may be one or more additional ocelli, which may be situated on little stalks. Examples of most of these are shown in their fig. 27. The authors say that this arrangement of antennae, palpus, and

ocelli arising from the eye-space suggests that the eye-space represents an imperfect duplication of the head. They add that until embryological study has been carried out it must remain uncertain whether all these structures arise from the imaginal disc of the compound eye or whether the imaginal discs of the palpus and ocelli contribute.

It seems more probable that the development of the imaginal disc is completely disorganised and may fail to form any specialised structure, or may form a small imperfect eye or its homologue; an antenna, or portions of it may develop independently and form various specialised organs, antennae, palpus, and ocelli.

In the squat mutation of *Drosophila melanogaster*, described by Bridges and Morgan, there is often an additional antenna, which has pushed its way completely or partially through the eye. This appears to be a by-product of this dominant gene.

III. Homoeosis and homoeotic reduplication.

In *Stylopyga orientalis* L. (Orthopt.) and *Tenebrio molitor* L. (Col.) Janda (1913) amputated the eye and found that one or more small antennae were regenerated in its place. Krizenecky removed the eye and optic ganglion in *Tenebrio molitor* and found that an antenna grew in its place. I do not know of any insect, in which homoeotic regeneration of this kind has taken place naturally.

IV. Reduplication.

Bilateral. I have separated the bilateral from the unilateral cases of reduplication, because, although some undoubtedly follow Bateson's Law and all of them may do so, it seems unlikely that they can be caused by injury with subsequent regeneration. Their symmetry suggests that they are due to a mutant gene, which causes an abnormal growth of the antennae, and if so they would belong to Group III. Their occurrence in different genera and even in different Orders does not militate against this, though one would expect more than one example to have been recorded in the same species. They may be compared with the *Prionus californicus* Motsch., figured by Bateson, in which each femur bore two tibiae and tarsi and both maxillary and the left labial palp were partially double. It is inconceivable that all six legs could have been injured in such a way as to cause duplication of the same kind, whereas reduplication of all or many of the legs in *Drosophila* is known to be determined by a recessive gene.

(*a*) *Antennae triple or partially triple.*

Bateson gives a full description with figures of the only two examples known to me. Both are nearly, but not quite, symmetrical.

Melolontha hippocastani F. (Col. Scarabaeidae). Male.

Odontolabis stevensi Th. (Col. Lucanidae). Female.

(*b*) *Antennae double or partially double.*

Macrotoma (*Prionus*) *senegalensis* Olivier (Col. Cerambycidae). Left antenna with first two segments normal, third expanded distally and having two articular surfaces. From the anterior two and from the posterior four segments arise, but both appear to have been broken. Right antenna with the first two segments normal and the third bifurcating near its proximal end.

The anterior branch bears seven and the posterior bears eight segments and both appear to be unbroken. (White, A., 1843, *Zoologist* **1** : 29, fig. with block reversed.)

Neodorcadion (*Dorcadion*) *egregium* Rttr (Col. CERAMBYCIDAE). Mongolia. The first segment of the right antenna bifurcates at the junction of the proximal and middle thirds into two branches of equal size. The anterior branch gives origin to a normal second segment and to a third segment narrower than a normal one, bent sharply backwards at a point near the proximal end, and with two constrictions, one near the proximal and the other near the distal extremity. The first segment of the left antenna bifurcates into two branches of equal size at a point nearly three-quarters of the way from the proximal end. The anterior branch gives origin to a normal second segment and to a third segment of about half the normal length bent sharply backwards at a point near the proximal extremity. From the posterior branch of each antenna ten segments of normal size arise, making eleven segments in all, which is the usual number. The specimen was exhibited before this Society by O. E. Janson (1916, *Proc. ent. Soc. Lond.* **1916** : lxxi). Redrawn and shown in the accompanying plate (fig. 1, × 4).

Carabus cancellatus Illig. (Col. CARABIDAE). Both antennae bifurcate at the same point, the tenth segment. (A. Sartorius, 1858, *Wien. ent. Monats.* **2** : 49.)

Rhynchites germanicus Herbst (Col. CURCULIONIDAE). The right antenna bifurcates at the tenth and the left at the ninth segment (lent to Bateson by Dr. Mason).

Unilateral reduplication.

In insects the antennae are frequently cylindrical and there is little difference between the anterior and posterior or the upper and lower surfaces. In the Lamellicorn beetles, however, there is great differentiation between the anterior and posterior surfaces, and as Kraatz pointed out, it is in this family that trifid antennae are commonest, though they are nearly as numerous in the CARABIDAE. As one would expect, the majority of cases clearly in accordance with Bateson's Law occur in Lamellicorns. Apart from the imperfect development of the extra parts in some triple antennae, their filiform character in most Coleoptera makes it impossible to prove that they follow Bateson's Law, though there can be little doubt that they do so. There is no need to redescribe those cases mentioned by Bateson or to give references to them. They are marked (B) in the following lists.

Antennae with two extra parts, which are clearly in secondary symmetry.

Rhizotrogus aequinoctialis Herbst	(Col. SCARABAEIDAE)	R	(B)
Geotrupes typhaeus L.	(,, ,,)	L	(B)
Amphimallus solstitialis L.	(,, ,,)	L	(B)
Melolontha vulgaris L.	(,, ,,)	R	(B)
M. vulgaris L.	(,, ,,)	L	(B)
M. vulgaris L.	(,, ,,)	R	(B)
M. vulgaris L.	(,, ,,)	L	(B)
Anomala junii Duft.	(,, ,,)	L	(B)
Polyphylla decemlineata Say	(,, ,,)	R	(B)
Phyllopertha horticola L.	(,, ,,)	R	(B)
Lichnanthe vulpina Hentz.	(,, ,,)	R	(B)
Navosoma sp.	(Col. CERAMBYCIDAE)	L	(B)

Mylabris pertinax Pering (Col. MELOIDAE). (Cockayne, 1925, *Trans. ent. Soc. Lond.* **1925** : 398, fig.).

Attacus cynthia Drury (Lepidopt. SATURNIDAE). Male. Right. An original antenna and two extra ones in secondary symmetry. (Lindner, 1915, *Z. wiss. InsektBiol.* **11** : 129.)

Antennae with two extra parts, the symmetry of which is not clear.

Carabus arvensis F. (Col. CARABIDAE) L 4 (B)
C. monilis F. (,, ,,) L 3 (B)
C. auronitens F. (,, ,,) L 7 (B)
C. sacheri Letzn. (,, ,,) R 7 (B)

Carabus auratus L. (Col. CARABIDAE). L. The third segment bifurcates and the anterior branch gives origin to seven segments, the seventh greatly swollen and giving rise to two branches, each consisting of four segments. The posterior branch gives origin to eight normal segments. (Gadeau de Kerville, 1910, *Bull. Soc. ent. Fr.* **1910** : 135.)

Carabus obsoletus Sturm var. *euchromus* Fald. L. First seven segments normal, eighth very greatly enlarged and distorted, with three articular surfaces, from which arise two branches of three segments each, and much farther away a branch of one segment. (Reineck, 1908.)

Carabus splendens F. R. The third segment is enormously expanded at the distal end and has three articular surfaces. From the anterior one springs a branch of eight segments, the first smooth and the others pubescent; from each of the other two spring two segments, the first smooth and the second pubescent. (Jeannel, R., 1905, *Bull. Soc. ent. Fr.* **1905** : 143.)

Chrysocarabus (*Carabus*) *auronitens* F. var. *zwicki* Heer. L. The seventh segment is dilated and has three articular surfaces giving off three branches, the superior and middle with two and the inferior with four segments. (Frivaldsky, 1889.)

Calosoma investigator L. (CARABIDAE) R 5 (B)
Anchomenus sexpunctatus L. (,,) L 6 (B)

Ptilonota guttata Mg. (Dipt. ORTALIDAE). The third segment is widened and partly separated into two by a deep horizontal sulcus. It consists of two segments fused. One gives origin to a normal but rather small arista, the other to two smaller aristae with their proximal ends fused. (Lamb, C. G., 1911, *Ent. mon. Mag.* **47** : 216, fig.)

Cordulegaster annulatus Latr. (Odonata). Female. L. antenna. The first and second segments are very broad, and from one angle of the second springs a normal terminal spine, while from the other angle spring two terminal spines arising close together. (Poujade, G. A., 1899, *Bull. Soc. ent. Fr.* **1899** : 44.)

Trachyderes variegatus Perty (Col. CERAMBYCIDAE). R. antenna. The second segment appears to be bifid, the anterior branch gives rise to nine segments, and from the posterior part spring two branches each of three segments. (Dallas, E. D., 1927, *Rev. Soc. ent. Argent.* **3** : 67, fig.; 1928, **6** : 55, fig.)

Clytus tricolor (CERAMBYCIDAE) L 7 (B)
C. arcuatus L. (,,) L 1 (B)

Luciola mingrelica Men. (Col. CANTHARIDAE). Left antenna, second segment bifid; broad anterior branch gives origin to 9 segments, narrow posterior branch to 3 segments, the third with two articular surfaces, from the anterior

of which arise 3 segments and from the posterior one. (Issajew, W. M., 1932, *Trav. Soc. Nat. Leningrad* **61** : 1, fig.)

Psammodes tuberculifer Hag. (Col. SCARABAEIDAE). Left antenna. Fifth segment elongated, apparently owing to fusion of three segments, and trifid, but none of the branches has any segments arising from it. (Reineck, G., 1908.)

Isocerus balearicus Schauf. (Col. TENEBRIONIDAE). Left antenna. Third segment large and expanded distally with two articular surfaces. From one spring 4 segments, and from the other 3, and from the third of these arise two terminal segments side by side. (Zoufal, V., and Formánek, R., 1904.)

Ancistrotus cummingi Hope (Col. CERAMBYCIDAE). Left antenna. Second segment continuous with next, which is greatly dilated and elongated by fusion of three or four segments, and has three articular surfaces. The anterior gives origin to one segment, the middle to one, and the posterior to two. (Dallas, E. D., 1927, *Rev. Chilena Hist. nat.* **31** : 12, fig.)

Pimelia sp. (Col. TENEBRIONIDAE). Right antenna. Third segment dilated distally with two articular surfaces, from the posterior of which springs a branch with 5 segments, and from the anterior a branch with 7, but the seventh is dilated and has two well-formed tips. (Reineck, 1908.)

Leucania pallens L. (Lep. NOCTUIDAE). Three antennae, one much thicker than normal and bifid at the end. (Newman, L. W., 1914, *Ent. Rec.* **26** : 127.)

Malachius marginellus F. (Col. CANTHARIDAE) L 2 (B)
Calopteron reticulatum F. (,, ,,) L 1 (B)

Cebrio dubius Rossi (Col. CEBRIONIDAE) L. 8th segment enlarged, 9th short, enlarged at apex, which has three tips, from one of which arises a segment like the normal terminal segment. (Chinaglia, 1911.)

Elater murinus Cand. (Col. ELATERIDAE) L 5 (B)
Dromoeolus barnabita Vill. (Col. EUCNEMIDAE) L 5 (B)
Ptinus latro F. (Col. PTINIDAE) L 5 (B)
Zonitis praeusta F. (Col. MELOIDAE) R 3 (B)
Scraptia fusca Latr. (Col. MORDELLIDAE) L 5 (B)
Pimelia scabrosa Sol. (Col. TENEBRIONIDAE) R 2 (B)
Blaps attenuata Fisch. (,, ,,) R 3 (B)
Dendarus hybridus Latr. (,, ,,) L 4 (B)
Helops coeruleus L. (,, ,,) R 5 (B)
Timarcha tenebricosa F. (Col. CHRYSOMELIDAE) R 9 (B)

Cicindela 10-*guttata* Fabr. (Col. CICINDELIDAE). The right antenna of this insect, a species from the Australian part of the East Indies, is normal for its first six segments; the seventh segment has two joints at its distal end and from the outer one arises a branch with four segments a little shorter than normal, but otherwise well formed, while from the inner one arises another branch of four segments. The first of these is very broad, short and thick, and the second is also shorter and thicker than a normal ninth segment, so that this may be a fused double structure. The figure shows the head rotated slightly to the right. (fig. 5, × 6 and part of the antenna under much greater magnification.)

Carabus violaceus L. (Col. CARABIDAE), Prague. The left antenna has the first two segments single, but the third segment bifurcates at its extreme base. From the anterior branch two segments spring, but the terminal one is very short and narrow, while from the posterior spring eight, which is the normal number. The total length of the antenna is a little less than that of the right one. The structure is too simple to show whether either branch is a single or

a fused double organ, but the thickness is no greater than that of a single one. (fig. 3, × 3.)

Carabus macrocephalus Dej. Reinosa (Col. CARABIDAE). The left antenna is single for the first eight segments and then bifurcates. The anterior branch consists of a single segment curved towards the posterior one, and the posterior branch consists of three well-formed segments, which is the correct number. There is no indication that either branch is a fused double one. (fig. 4, × 3.)

Callidium clavipes Fabr. (Col. CERAMBYCIDAE). The right antenna has the first two segments normal, but the third is greatly thickened and beyond this the antenna is double. The anterior branch appears to have only five segments, but the last three are so ill-formed and poorly sclerotised that there may be more. The posterior branch has eight well-formed segments, which is the usual number, and is very little reduced in length. There is no indication that either branch is a fused double antenna. (fig. 2, × 3.)

Cicindela sylvicola Dej. (Col. CICINDELIDAE) L 8 (Lopez, C., 1891, *Riv. ital. Sci. nat.* **11** : 22)
C. sylvatica L. (,, ,,) R 3 (B)
Procrustes coriaceus L. (Col. CARABIDAE) L 7 (B)
P. coriaceus L. (,, ,,) L 5 (B)
Calosoma sycophanta L. (,, ,,) L 9 (B)
C. triste Lec. (,, ,,) R 6 (B)
C. inquisitor L. (,, ,,) R 8 One branch apparently double (Reineck, 1908)
Carabus sylvestris F. (,, ,,) R 8 (B)
C. auratus L. (,, ,,) R 2 (B) (Kraatz)
C. auratus L. (,, ,,) R 5 (B) (Doumerc)
C. auratus L. (,, ,,) L 8 (B) (Perty)
C. italicus Dej. (,, ,,) L 8 (B)
C. exaratus Quens. (,, ,,) L 5 (B)
C. intricatus L. (,, ,,) L 9 (B)
C. emarginatus Duft. (,, ,,) L 2 (B)
C. catenulatus Scop. (,, ,,) L 8 (B)
C. intricatus L. (,, ,,) L 4 (Frivaldsky, 1889)
C. cancellatus Ill. var. *moestus* Dej. (,, ,,) R 6 (Frivaldsky, 1889)
C. violaceus L. var. *purpurascens* F. (,, ,,) R 5 (Della Beffa, 1910)
C. scheidleri Panz. (,, ,,) L 3 (Tornier, 1900)
C. preissleri Dej. (,, ,,) L 4 (Tornier, 1900)
C. cancellatus Ill. (,, ,,) R 9 (Chinaglia, 1911)
C. hispanus F. (,, ,,) L 4, one branch double thickness (Reineck, 1908)
C. concatenatus Panz. (,, ,,) L 7 (Reineck, 1908)
Nebria sp. (,, ,,) (B)
Scarites subterraneus F. (,, ,,) L 9 (Tornier, 1900)
Broscus cephalotes L. (,, ,,) L 10 (Tornier, 1900)
B. politus Dej. (,, ,,) R 3 (Reineck, 1908)
Ditomus tricuspidatus F. (,, ,,) R 8 (B)
Harpalus calceatus Duft. (,, ,,) R 9 (B)
Abax schueppeli Palli. (,, ,,) R 2 (Frivaldsky, 1889)
Pterostichus planipennis Apfb. (,, ,,) R 9 (B)

Anchomenus albipes F. (Col. CARABIDAE) L 10 (B)
A. angusticollis F. (,, ,,) R 8 (B)
Agonum viduum Panz. (,, ,,) R 6 (B)
Galerita collaris Latr. (,, ,,) R 8 (Dallas, 1928)
Ilybius obscurus Marsh. (Col. DYTISCIDAE) R 8 (Henriksen, 1915, *Ent. Medd.* **10** : 210)
Colymbetes coriaceus Aub. (,, ,,) R 5 (B)
Dytiscus marginalis L. (,, ,,) L 3 (Tornier, 1910)
Batrisus delaportei Aub. (Col. PSELAPHIDAE) R 10 (Frivaldsky, 1889)
Brachygluta lefebvrei Aub. (,, ,,) L 9 (Della Beffa, 1910)
Prionocerus coeruleipennis Perty. (Col. CANTHARIDAE) R 1 (Keyl, E., 1913, *Tijds. Ent.* **56** : 1)
Luciola lusitanica Charp. (,, ,,) L 1 (Chinaglia, 1911)
Photuris trilineata Say. (,, ,,) R (Cockayne, 1925)
Telephorus lividus L. (,, ,,) L 2 (B)
T. rotundicollis Say. (,, ,,) R 2 (B)
Cantharis rustica Fall. (,, ,,) (Zoufal and Formánek, 1904)
Lycus sp. (,, ,,) L 1 (B)
Monotoma quadricollis Aub. (Col. CUCUJIDAE) R (B)
Cryptophagus scanicus L. (Col. CRYPTOPHAGIDAE) R 9 (B)
C. dentatus Herbst. (,, ,,) L 3 (B)
Sarrotrium clavicorne L. (Col. COLYDIIDAE) L 1 (Tornier, 1900)
Corymbites tesselatus L. (Col. ELATERIDAE) L 8 (Tornier, 1900)
Elater hirtus Herbst. (,, ,,) L 9 (B)
Ampedus ephippium Ol. (,, ,,) R 6 (B)
Julodis clouei Buquet. (Col. BUPRESTIDAE) R 5 (B)
Zonabris quadripunctata L. (Col. MELOIDAE) L 6 (B)
Sepidium tuberculatum. (Col. TENEBRIONIDAE) L 5 (B)
Akis punctata Thunb. (,, ,,) L 3 (B)
Blaps chevrolati Sol. (,, ,,) L 7 (B)
B. cylindrica Herbst. (,, ,,) L 3 (B)
B. similis Latr. (,, ,,) R 8 (B)
B. gibba F. (,, ,,) L 5 (Chinaglia, 1911)
Phylax tristis Rossi. (,, ,,) R 7 (Clermont, J., 1907, *Bull. Soc. ent. Fr.* **1907** : 237)
Nyctelia puncticollis Waterh. (,, ,,) (Dallas, 1928)
Torneutes pallidipennis Thomas. (Col. CERAMBYCIDAE) R 3 (Dallas, 1928)
Prionus sp. (,, ,,) R 10 (B)
Polyarthron plutschewskyi Jak. (,, ,,) R 10 (Reineck, 1908)
Pachyta quadrimaculata L. (,, ,,) R 2 (Planet, 1893, *Le Naturaliste* **7** : 275)
Gaurotes virginea L. (,, ,,) R 1 (Reineck, 1908)
Anoploderma wagneri Waterh. (,, ,,) R (Dallas, 1928)
Leptura tesserula Charp. (,, ,,) L (Frivaldsky, 1889)
L. attenuata L. (,, ,,) R 1 (Zoufal and Formánek, 1904)
Strangalis atra F. (,, ,,) L 1 (B)
S. calcarata F. (,, ,,) ? (B)
Hammaticherus heros F. (,, ,,) L 7 (B)
Cerambyx cerdo L. (,, ,,) L 6 (B)
C. scopolii Fuessl. (,, ,,) R 3 (B)

Tetropium gabrieli Weise. (Col. Cerambycidae) R (Pool, C. J. E., 1917, *Proc. zool. Soc. Lond.* **1917** : 97)
Callidium variabile L. (,, ,,) L 3 (B)
Aromia moschata L. (,, ,,) L 6 (B) (Kraatz)
A. moschata L. (,, ,,) R 2 (B) (Mocquerys)
A. moschata L. (,, ,,) L 5 (B) (lent by Janson)
A. moschata L. (,, ,,) R 5 (Tornier, 1900)
Purpuricenus koehleri F. (,, ,,) R 1 (Planet, 1892, *Le Naturaliste* **6** : 50)
Clytus arcuatus L. (,, ,,) R 5 (B)
Neoclytus cupraea Say. (,, ,,) R 1 (Ehrmann, 1900, *Ent. News* **11** : 619)
Dorcacerus barbatus Oliv. (,, ,,) R 9 (Dallas, 1928)
Trachyderes succinctus L. (,, ,,) R 3 (Reinhardt, 1911, *Ent. Blatt.* **7** : 113)
Lamia textor L. (,, ,,) L 1 (B)
Chreostes quedenfeldti Kolbe. (,, ,,) L 8 (Tornier, 1900)
Saperda carcharias L. (,, ,,) L 3 (Gressner, 1886–7, *J. Ber. Westfäl. Provinzial-Ver.* **15** : 32; 1886, *Stettin. ent. Ztg* **47** : 166, fig.)
Oberea oculata L. (Col. Cerambycidae) R 2 (Zoufal and Formánek, 1904)
Solenophorus strepens. (,, ,,) R 2 (B)
Chrysomela cacaliae Schrank. (Col. Chrysomelidae) L 7 (B)
Adimonia tanaceti L. (,, ,,) L 5 (B)
Phyllobius pilicornis Desbr. (Col. Curculionidae) R double club (Frivaldsky, 1889)
Lucanus cervus L. (Col. Lucanidae) L 3 (B) (Gadeau de Kerville)
L. cervus L. (,, ,,) L 1 (B) (von Heyden)
Chiasognathus granti Steph. (,, ,,) L 6 (B)
Macrognathus nepalensis Hope. (,, ,,) R 3 (B)
Phyllognathus silenus F. (,, ,,) R 2 (Della Beffa, 1910)
Nigidius sp. (,, ,,) R 2 (B)
Melolontha vulgaris L. (Col. Scarabaeidae) L 2 (B)

Tenthredopsis nassata Klug (Hymenopt. Tenthredininae). R 1 (Jacobs, J. C., 1881, *C.R. Soc. ent. Belge* **1881** : xcvi)

Myrmica ruginodis Nyl. (Hymenopt. Formicidae). L. Branch from inner aspect of scape. (Donisthorpe, H., 1922, *Ent. Rec.* **34** : 81)

Cerastis ligula Esp. (Lep. Noctuidae). L. double. (Hayward, 1906, *Entomologist* **39** : 294).

Lymantria monacha L. (Lep. Lymantriidae). L. antenna very thick with four instead of two pectinations on the sides of each segment, and with a small imperfect branch springing from the dorsal surface near the junction of the proximal quarter with the distal three-quarters. (Lindner, 1915, *Z. wiss. InsektBiol.* **11** : 129.)

Arrangement of extra parts unclassifiable.

Melolontha vulgaris L. (Col. Scarabaeidae). There is an irregular repetition of a pair of clubs peripheral to the normal antenna. The normal antenna ends at segment 10, then the antenna continues with six segments in reverse order, from 6 to 1, and then again with six more segments in normal order,

from 1 to 6. Original description (Mocquerys, 1880, *Col. Anorm.* : 12, fig.). Redescribed and refigured by Bateson.

Arrangement undescribed.

Zygaena lonicerae Esp. (Lep. ZYGAENIDAE). Four antennae. (Couldwell, C., 1919, *Naturalist* **44** : 162.)

Zygaena sp. (Lep. ZYGAENIDAE). Two normal antennae and a third. (Schultz, O., 1897, *Ill. Wochenschr. Ent.* **3** : 631.)

Crambus alpinellus Hb. (Lep. PYRALIDAE). Three antennae. (*Ibid.*)

It is generally accepted that reduplication of one antenna is due to regeneration after an injury received during an early stage of development. The lists given in this paper, comprising Coleoptera 152, Lepidoptera 7, Hymenoptera 2, Diptera 1, and Odonata 1, afford strong support for this belief. The uncertain number of *Drosophila* with reduplicated antennae of this kind need not be taken into account because this insect has been bred in vast numbers and countless thousands have been examined microscopically.

Many Hymenoptera spend their larval life as internal parasites or protected inside cells, and in addition the antennae are reduced to small papillae or absent, while in sawflies, though many of their larvae live exposed, the antennae are very small. The larvae of Lepidoptera and of some Diptera have very short antennae, and those of other Diptera have the antennae reduced to mere papillae. These facts probably account for the paucity of records in these Orders. The rarity of reduplication of the antennae in Lepidoptera is real, for they are examined in greater numbers than members of any other Order and double or triple antennae would be very conspicuous in them.

Some families of Coleoptera, such as the CURCULIONIDAE, possess as larvae antennae, which are mere papillae, and also live protected lives. The larvae of others, such as the CERAMBYCIDAE and MELOLONTHINAE, have short antennae, but they have a very long larval life, which increases the risk of injury, while the campodeiform larvae of the CARABIDAE not only have long antennae, but are particularly exposed to damage in the pursuit of their prey.

It is therefore not surprising to find that out of the 152 examples 46 occur in the CARABIDAE, 33 in the CERAMBYCIDAE, and 20 in the Lamellicornia. Of the remainder many have campodeiform larvae and live exposed lives. The frequency of reduplication of antennae in the different families of Coleoptera seems to be closely correlated with the duration and character of their lives and with the length of the antennae of their larvae.

It will be noted that with one exception, a dragonfly, all the cases of unilateral reduplication occur in holometabolous insects. One would expect it to be quite as common in insects which have an incomplete metamorphosis or none at all, for many of them have long antennae in every instar and their mode of life exposes them to the risk of injury. I cannot explain why this kind of abnormality is so very rare in ametabolous and hemimetabolous insects.

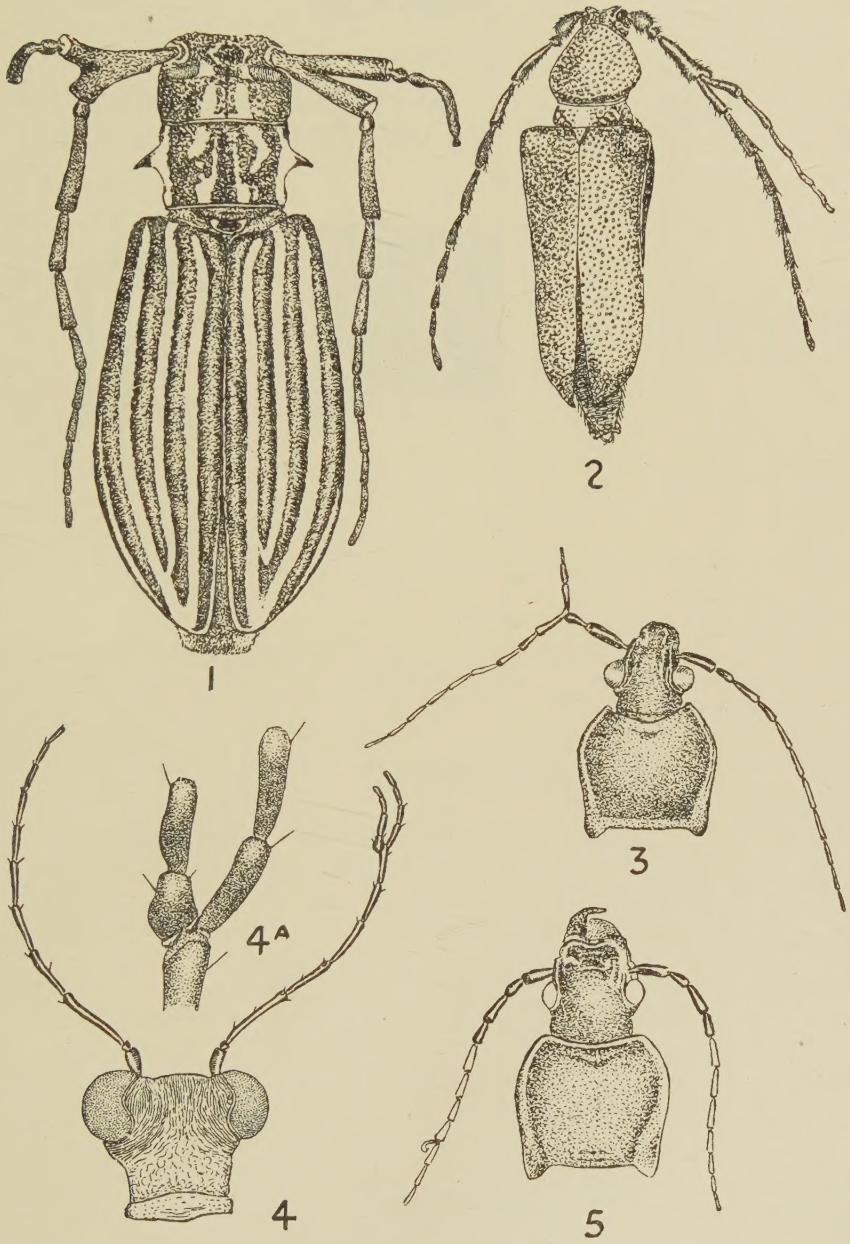
The generic and specific names used in this paper are those used by the original describers, and the general order of families in the Coleoptera is that adopted by von Heyden, Reitter, and Weise in their *Catalogus Coleopterorum Europae*, 1908.

References.

Bateson, W., 1894, *Materials for the Study of Variation.*
Bridges, C. B., and Morgan, T. H., 1919, The Second Chromosome Group of Mutant Characters in *Drosophila melanogaster*. *Publ. Carnegie Inst. Wash.* **278** : 284.
Chinaglia, L., 1911, *Bull. Mus. Zool. Anat. Torino* **26** (637) : 1.
Dallas, E. D., 1928, *Riv. Soc. ent. Argent.* **4** : 55.
de Baillon, P. Cappe, 1927, Recherches sur la Tératologie des Insectes. *Encyclop. ent.* (A) **8.**
Della Beffa, G., 1910, *Riv. Col. Ital.* **8** : 129.
Frivaldsky, J., 1889, *Term. Füzetek.* **12** : 72.
Janda, V., 1913, *Arch. EntwMech.* **36** : 1.
Křiženecký, J., 1911, *Ent. Blätt.* **7** : 113.
——, 1912, *Zool. Anz.* **39** : 579.
——, 1913, *ibid.* **42** : 20.
——, 1913, *Arch. EntwMech.* **37** : 629.
Morgan, T. H., Bridges, C. B., and Sturtevant, A. H., 1925, The Genetics of Drosophila. *Bibliog. Genet.* **2** : 70.
Reineck, G., 1908, *Deuts. ent. Z.* **52** : 487.
Reinhardt, L., 1911, *Ent. Blätt.* **7** : 113.
Tornier, G., 1900, *Arch. EntwMech.* **9** : 501.
Zoufal, V., and Formanek, R., 1904, *Vestnik. cesk. klub. prir. Prostjove.* **7** : 73.

Explanation of Plate 1.

Fig. 1. *Neodorcadion egregium* Rttr. (×4).
2. *Callidium clavipes* Fabr. (×3).
3. *Carabus violaceus* L. (×3).
4. *Cicindela* 10-*guttata* Fabr. (×6). 4*a*. Part of the antenna under much greater magnification.
5. *Carabus macrocephalus* Dej. (×3).



Supernumerary antennae in insects.